DRY TABLE - PYRITE REMOVAL FROM COAL

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INTRODUCTION

An awareness for particle segregations in material handling equipment is usually the result of negative experiences. Preventing demixing of a ganular composite which is moving through bins, feeders, stockpiles, etc., generally leads to frustration. Three factors determine the extent of particle segregation in these situations,

- the physical configuration of the material handling equipment,
- the forces which convey the particles through that equipment,
- and the differences between the particles in one or more of their physical properties (size, shape, bulk density, resiliency and surface roughness).

The following described equipment, specifically designed as a separator for dry particulates combines the above factors to exploit this inherent segregation within moving particle beds.

EQUIPMENT DESCRIPTION

Figure 1 contains a perspective drawing of the Dry Table and a cross-section through the unit illustrating the particle bed. The drive unit for the table is an electro-mechanical exciter of the type used for vibrating feeders. In fact, this recently developed coal cleaning unit is a feeder, but with the following design differences.

- The deck surface is short but very wide.
- The coal is inserted at one side of the feeder's deck.
- The conveying force is reversed, it feeds the material into its backwall.
- The particle bed's net flow is from one side of the feeder to the other side.
- The deck is non-symmetrical about the vertical plane passing through its center of gravity and the exciter's line of drive.

Coal is fed onto the longest side of the unit and the conveying force from the drive moves the particles towards the backwall. A large pile of particles forms against the backwall, filling the entire trough. Gravity moves the particles on the pile's surface down the open slope as the conveying force continues to drive the underlying material against the backwall. The result is the continuous overturning of the bed. The pressure of the incoming feed forces the overturning bed to flow across the deck away from the feed side in a helical motion. And because the deck's length diminishes (tapers) in this direction, the toe of pile is being continuously discharged. Simultaneously, size and bulk density separations are occurring in the overturning bed. The large or low density particles move into a spiralling path that migrates towards the toe of the pile, Section A-A of Figure 1, whereas the small or high density particles move into a smaller spiral and concentrate towards the backwall. Those particles that are both large and of low density, coal, advance past the large and high density particles, rock and pyrite, and prevail in obtaining positions at the toe of the pile. Also small particles of pyrite will concentrate at the backwall in preference to small particles of coal.

The overall resulting discharge from the horizontal deck portion of the unit is a series of staggered particle size gradations of different densities. To avoid this overlapping of the size gradations of the rock and pyrite with the coal, the feed to the unit is presized to definite size ranges. For the coal, rock and pyrite separation, the usual top size to bottom size of the feed particles in any one pass is a 4 to 1 ratio (8" x 2", 2" x 1/2", etc.), the rock-coal size gradations are usually controlling this ratio.

The particles discharge from the nearly horizontal deck onto an attached downward sloping surface referred to as the "discharge lip". This "lip" can make further separations based on particle shape, resiliency and surface roughness if desired. The shape separation is based on the cubical coal particles being unstable on the "discharge lip" and the near tabular rock and pyrite particles being stable when the unit is vibrating. The unstable coal will thus be discharged by rolling off the "lip" while the tabular rock and pyrite are conveyed back up the lip into the pile. The surface roughness of the highly mineralized particles is greater than that for the clean coal particles. This additional roughness aids in conveying the rock and pyrite back into the deep particle bed; whereas, the slick coal tends to slip off the "lip". Generally, the resiliency of the coal is greater than that of the rock particles. The conveying vibrations causes the more resilient coal particles to bounce and assure their unstability on the "discharge lip".

The Dry Table has a discharge similar in character to that of a wet concentration table in that it is a gradation from a clean coal product through mineralized particles to pyrite along the discharge edge. This dry method of separation is functional over a broad span of particle sizes. The limiting factor for the minimum size particles is the formation of particle agglomerations due to electrostatic charges or surface moisture. No limiting factor has been encountered for the maximum size particles. The present practical range in coal preparation is 1/8" to 8".

The majority of the Dry Table experience is in the reduction of the ash content of coals. However, there has been a recent increase of inquiries into the use of the Dry Table as a method for sulfur reduction.

EXPERIMENTAL SECTION

Runs were made with the following described samples by passing them through the 12" lab unit or the 8' pilot plant unit Dry Table in one pass and collecting the discharge as multiple products. In Figure 1, an eleven product discharge is shown, "A" through "K", where the discharges are of equal increments spaced along the "discharge lip". Each discharge product was analyzed for ash, pyritic sulfur and BTU content, following the accepted ASTM methods D-271 and D-2492. The analytical results were used to construct the distribution curves shown in the graph. The coal samples used are a cleaned New Mexico Bituminous Coal and a raw Arizona Subbituminous Coal. Both samples were screened to a 4:1 size range prior to running on the Dry Tables.

RESULTS

The data for the Bituminous and Subbituminous examples are shown in Graph I, "Dry Table Discharge Distribution". The horizontal axis for both the upper and lower portions of the graph represents the discharge from the Dry Table as the eleven discharge products. In the upper portion, the vertical axis gives the recovery as a percentage of the original feed for heating content (BTU), ash and pyrite. The clean coal product is the accumulation of discharge products starting at the far left (percentage on left vertical axis) and the reject starts on the far right (right vertical axis). The data points plotted on the graph are for a run which had an eight product discharge. In the lower portion of the graph, separate curves are plotted for Product and Reject which shows the distribution for the pyritic sulfur as pounds per million BTUs. The composition of the feeds are:

	Bituminous	Subbituminous
BTU/lb	13,460	8,060
Ash, %	10.1	25.8
Pyritic Sulfur, %	0.44	0.19

DISCUSSION

As with all coal cleaning equipment, the performance is a function of the coal being cleaned. The Dry Table is no exception to this and can even be considered more sensitive because it uses as many as five of the particles' physical properties for separation rather than just the density alone. Also affecting the separation is the degree to which the major constituents of the raw coal (clean coal, rock and pyrite) are liberated, one from the other. The performance of the Dry Table is based on the probability of particle movements. Therefore, the proportion of mineralized particles removed is constant for any specific coal feed over a wide range of compositions.

The pyrite in the two examples selected for this discussion is unliberated and of relatively low concentration. The lettered discharge products "A" through "K", are divisions of the Dry Table's discharge arbitrarily selected for analytical and discussion purposes. The large number of product divisions, or their specific boundaries need not be used in actual coal cleaning applications.

Subbituminous coal. The only preparation this coal received prior to being fed to the Dry Table was the presizing into 4:1 size ranges. The sequence of the distribution curves, upper Graph 1, show that in this three component system, clean coal (BTU) - rock (ash) - pyrite, the major separation is between the clean coal and the rock. The pyrite-ash separation is reversed to what would be expected for the more dense pyrite, which further demonstrates that the pyrite is not liberated. There are three zonal types of discharge from the Dry Table with this coal. In the first zone, product discharges "A" and "B", the coal contains low ash and has the pyrite mainly associated with the coal. In the second zone, product discharges "C" through "G", the coal contains low pyrite and ash but the pyrite is associated with the ash. In the third zone, product dishcarges "H" through "K", the discharge contains a coal and rock mixture where the pyrite is associated with both coal and rock at higher concentrations.

Selecting discharges "A" through "I" as a clean coal product, "J" and "K" as reject, gives a 90% recovery of the coal's potential heating content, and removals of 74% of the ash and 50% of the pyrite. The compositions of the Product and Reject are:

	Product	Reject
Yield, %	72	28
BTU/lb	10,360	2,160
Ash, %	10.8	64.1
Pyritic Sulfur, %	0.13	0.32

With the discharge split into just a clean coal product and a rejct, the well known compromise must be made between recovering as much clean coal as possible while rejecting most of the rock and pyrite. With the Dry Table, however, it is possible to have as many products as found to be reasonable. Therefore, one could select the zone of low ash content "A" through "G" as the clean coal product and "H" through "J" for retreatment where there is a mixture of both rock and coal and "K" as the reject which essentially contains no usable heat.

	Product	Retreatment	Reject
Yield, %	47	37	16
BTU/lb	11,260	7,390	0
Ash, %	4.7	30.0	78
Pyritic sulfur, %	0.08	0.27	0.29

Both the clean coal "product" and the "reject" are desirable in this arrangement and its success depends upon the character of the "retreatment" discharge. In this particular case the "retreatment" is a mixture of clean coal and liberated rock with a small amount of middlings. The "retreatment" can be recycled through the same unit or sent to another unit for a second pass.

Bituminous. This coal is the product from a preparation plant, and therefore, there is essentially no liberated pyrite or rock present. The sequence of the curves shows that the unliberated pyrite is unevenly distributed among the coal particles and that the major separation is between the clean coal and pyrite. The ash and BTU curves are very similar, except for a slight difference in slopes, showing that there is a near constant inherent ash in the coal for the discharge products "A" through "H". The pyrite curve is quite different in shape and shows small amounts of pyrite in discharge products "A" through "D", increasing amounts in "E" to "J", and substantial quantities in "K". There are four zonal types of discharge for this particular separation. In the first zone, discharge products "A" through "D", the coal has a minimum ash and pyrite content. In the second zone, discharge products "D" to "H", the coal contains a minimum of ash, but has an increasing pyrite content. In the third zone, discharge products "I" through "J", the ash and pyrite content progressively increase in the coal. In the fourth zone, discharge product "K", the coal is highest in both ash and pyrite, and contains all the misplaced "sink" material from the wet washing process.

The specific gravity difference between the first and second zones is quite small, so the separation is most likely caused by the other physical properties of the particles. Since the ash difference is also small, it is assumed that the presence of the pyrite is related to the physical property differences which the Dry Table can distinguish for separation purposes. The suggested method of processing is to collect the discharge from discharge products "A" to "H" as a clean coal product and "I" to "K" for retreatment.

	Product	Retreatment
Yielt, %	75	25
BTU/lb	13,750	12,600
Ash, %	7.5	17.5
Pyritic sulfur, %	0.22	1.08

For this coal sample the "retreatment" discharge should not be processed as a second pass on the Dry Table because little benefit would be realized in ash and pyrite reduction. The best approach would be the recycling of this material to the wet preparation plant after crushing.

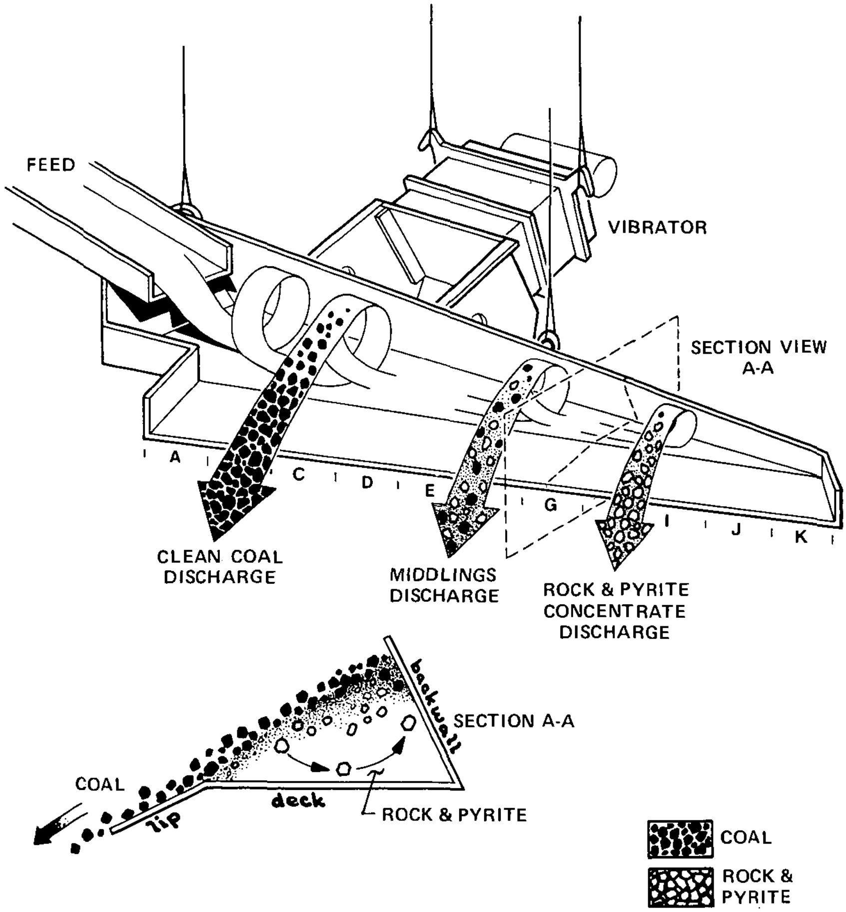
CONCLUSION

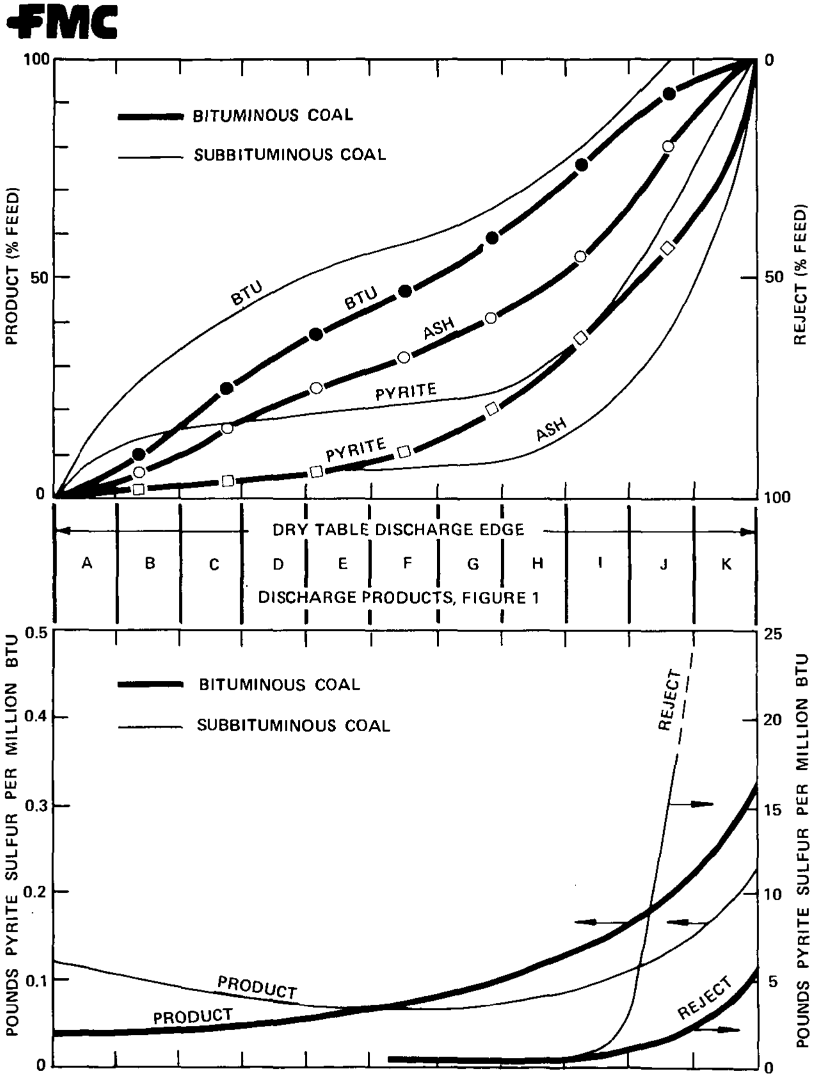
The Dry Table can reduce the sulfur content in a coal through pyrite removal. The extent of the coal-pyrite separation will be a function of pyrite liberation and the physical property differences between the free flowing coal and pyrite particles. However, there are cases where even coal containing unliberated pyrite can be separated into coal products of low and high pyritic sulfur contents.

The Dry Table is best employed as a rougher, it has a separation performance similar to that of a Baum Jig. It can be used alone or in conjunction with existing coal cleaning equipment. And it is especially applicable where the use of water is restricted due to limited supply, freezing, or costly treatment prior to discharge or reuse.

FIGURE 1

DRY TABLE PRINCIPLE; SCHEMATIC VIEW





GRAPH I – DRY TABLE DISCHARGE DISTRIBUTION